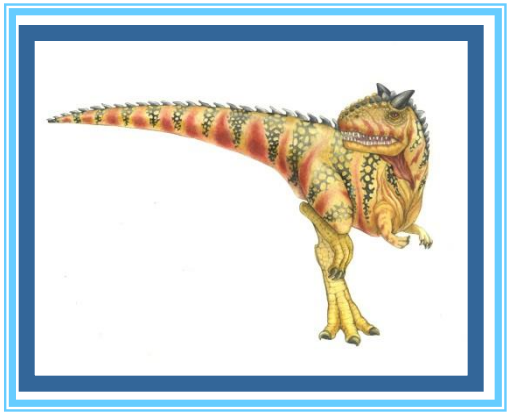
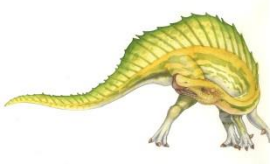
Chapter 15: Security

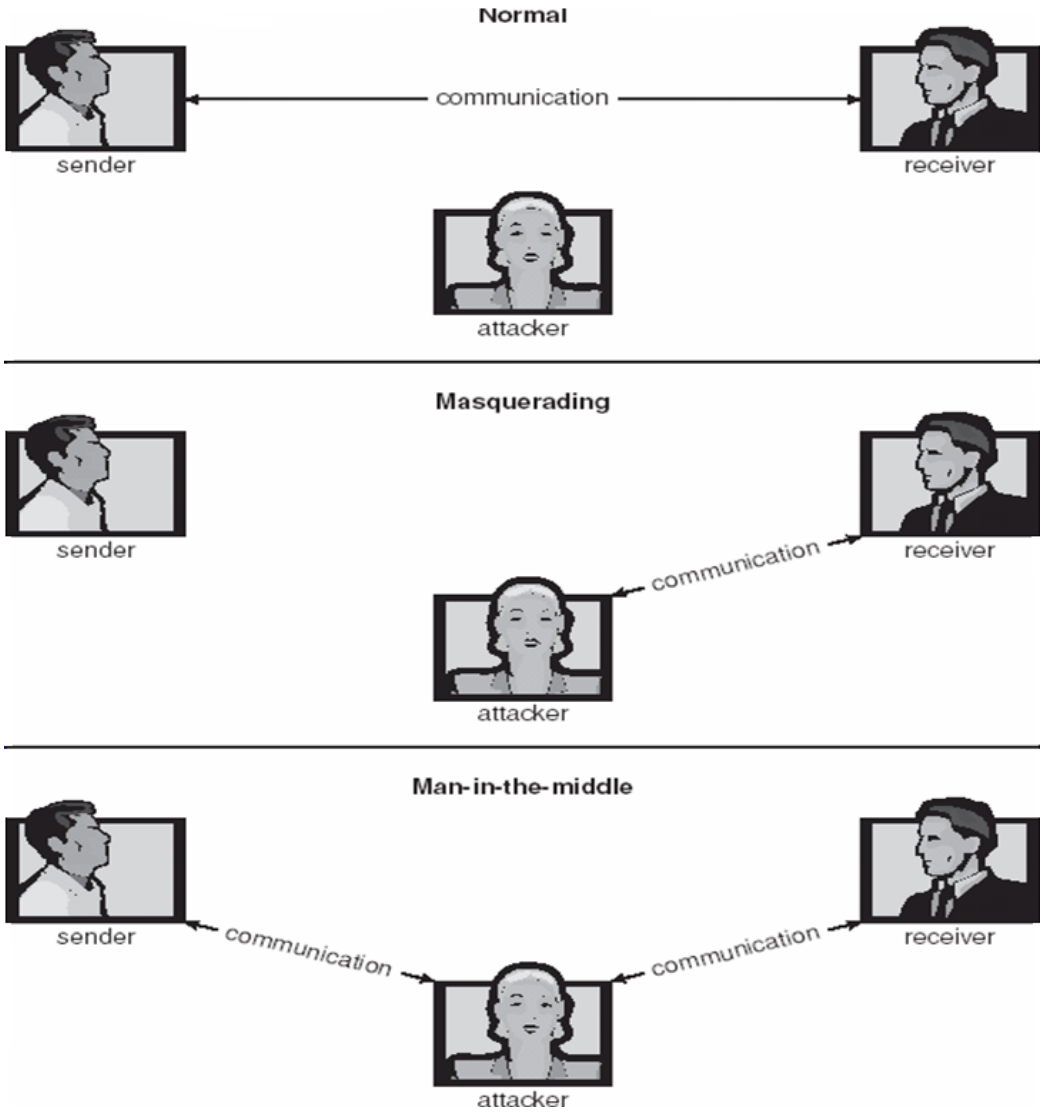


Security Violations

- Categories
  - **Breach of confidentiality**
  - **Breach of integrity**
  - **Breach of availability**
  - **Theft of service**
  - **Denial of service**
- Methods
  - **Masquerading (breach authentication)**
  - **Man-in-the-middle attack**

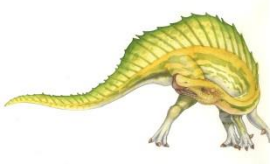


Standard Security Attacks



Program Threats

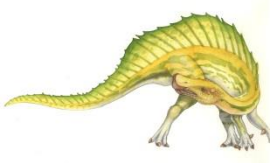
- Trojan Horse
  - Code segment that misuses its environment
  - **Spyware, pop-up browser windows, covert channels**
- Trap Door
  - Specific user identifier or password that circumvents normal security procedures
  - Could be included in a compiler
- Logic Bomb
  - Program that initiates a security incident under certain circumstances
- Stack and Buffer Overflow
  - Exploits a bug in a program (overflow either the stack or memory buffers)



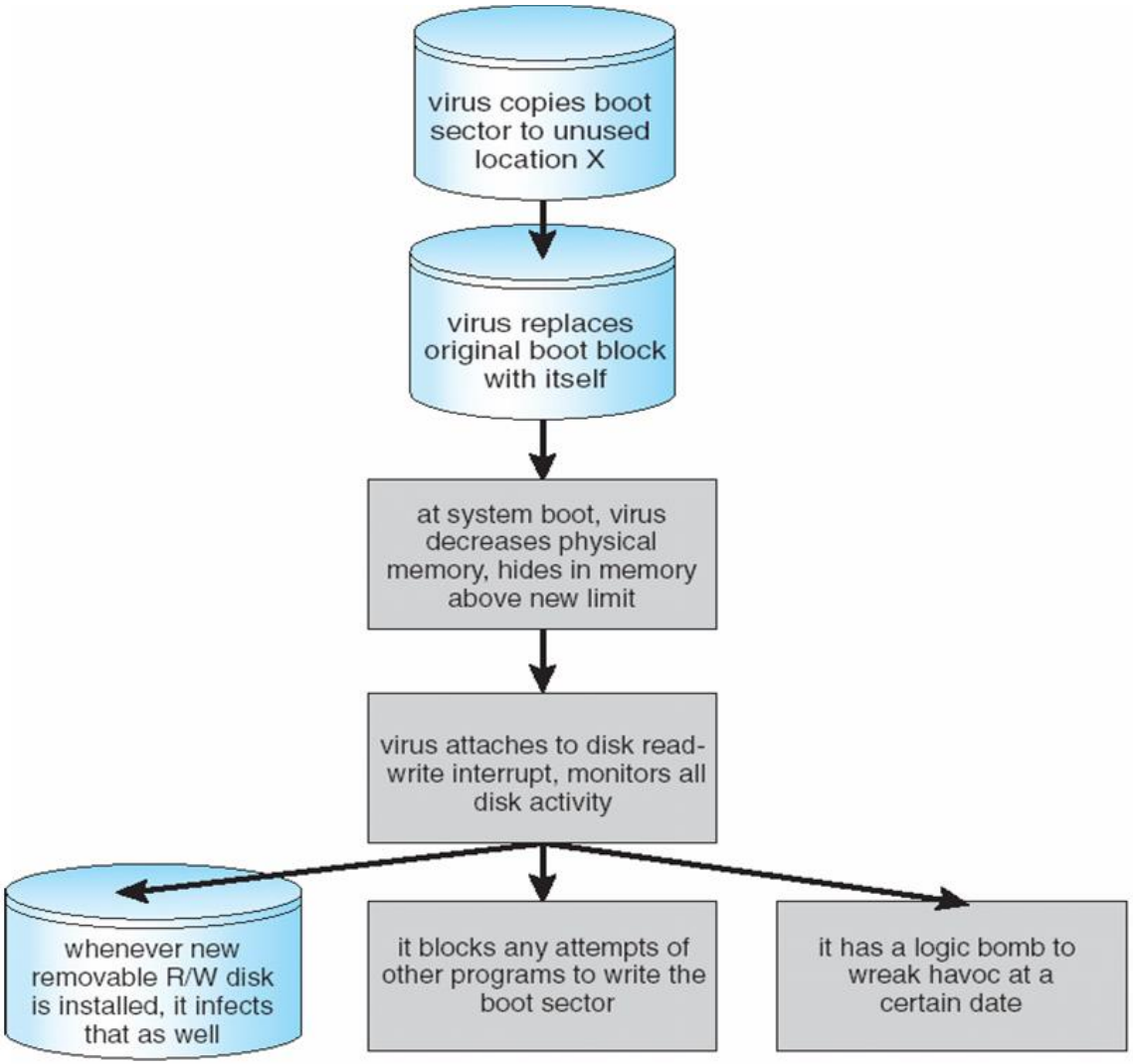
Program Threats (Cont.)

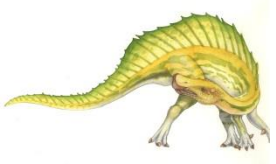
- Viruses
  - Code fragment embedded in legitimate program
  - Very specific to CPU architecture, operating system, applications
  - Usually borne via email or as a macro
    - Visual Basic Macro to reformat hard drive

```
Sub AutoOpen()
Dim oFS
  Set oFS = CreateObject(''Scripting.FileSystemObject'')
  vs = Shell(''c:command.com /k format     c:'',vbHide)
End Sub
```



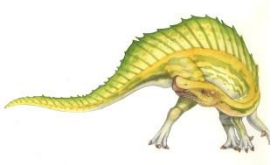
A Boot-sector Computer Virus





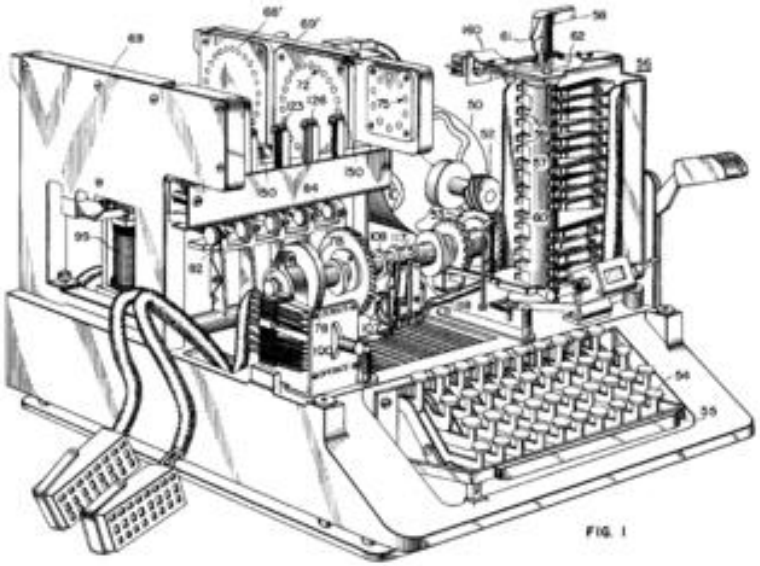
Cryptography as a Security Tool

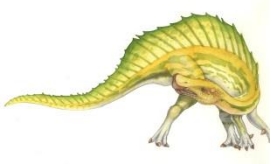
- Broadest security tool available
  - Source and destination of messages cannot be trusted without cryptography
  - Means to constrain potential senders (*sources*) and / or receivers (*destinations*) of *messages*
- Based on secrets (**keys**)



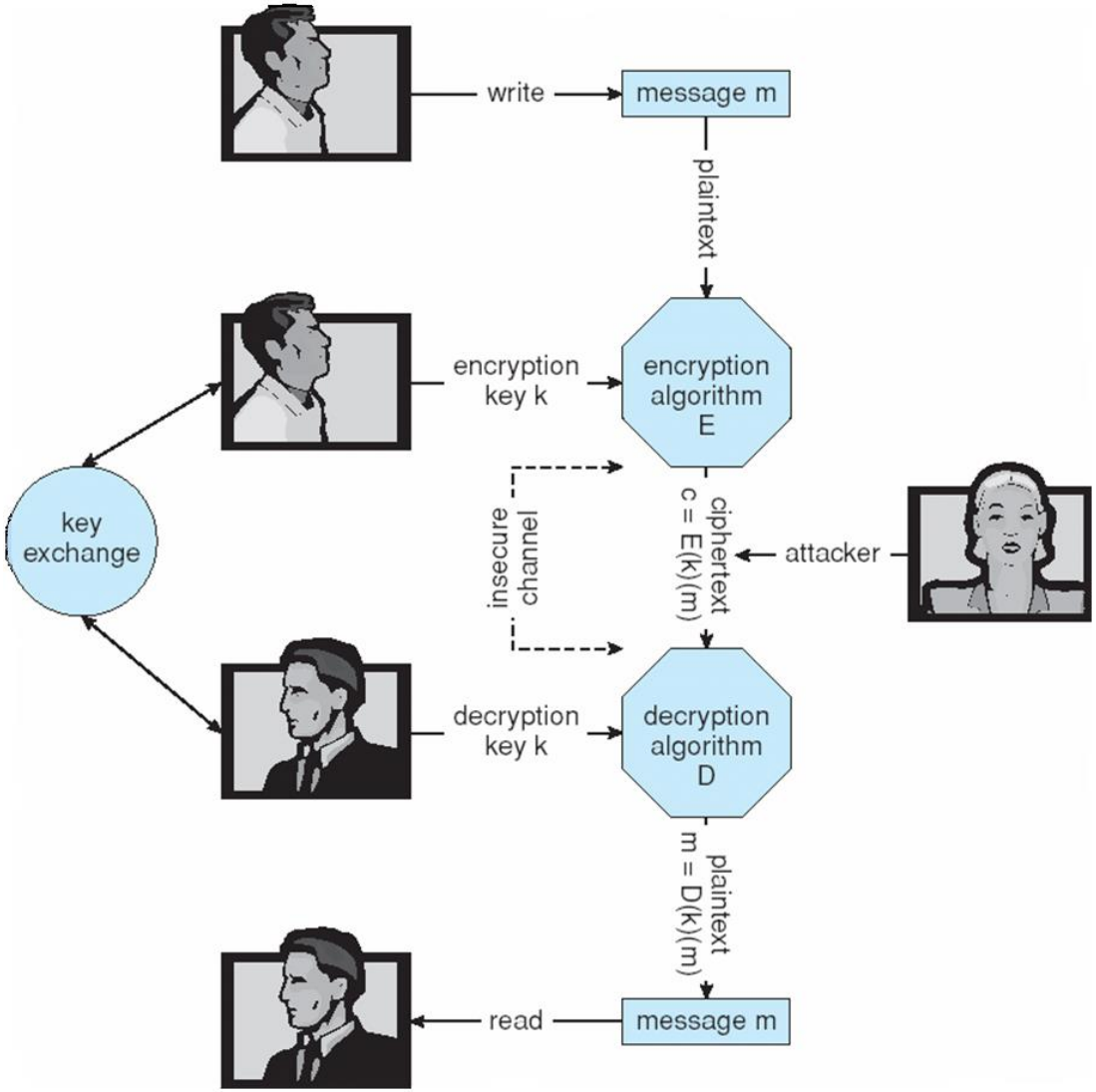
Early Cryptography

normal alphabet: a b c d e f g h i j k l m n o p q r s t u v w x y z
cipher alphabet: c i p h e r s t u v w x y z a b d f g j k l m n o q



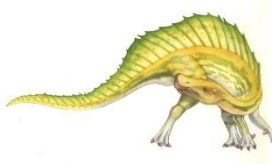


Secure Communication over Insecure Medium



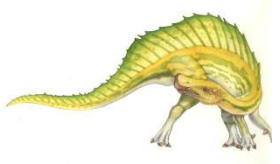
Encryption

- Encryption algorithm consists of
  - Set of K keys
  - Set of M Messages
  - Set of C ciphertexts (encrypted messages)
  - A function $E : K \rightarrow (M \rightarrow C)$. That is, for each $k \in K$, $E(k)$ is a function for generating ciphertexts from messages.
    - Both E and $E(k)$ for any k should be efficiently computable functions.
  - A function $D : K \rightarrow (C \rightarrow M)$. That is, for each $k \in K$, $D(k)$ is a function for generating messages from ciphertexts.
    - Both D and $D(k)$ for any k should be efficiently computable functions.



Encryption

- An encryption algorithm must provide this essential property: Given a ciphertext $c \in C$, a computer can compute m such that $E(k)(m) = c$ only if it possesses $D(k)$.
  - Thus, a computer holding $D(k)$ can decrypt ciphertexts to the plaintexts used to produce them, but a computer not holding $D(k)$ cannot decrypt ciphertexts.
  - Since ciphertexts are generally exposed (for example, sent on the network), it is important that it be infeasible to derive $D(k)$ from the ciphertexts

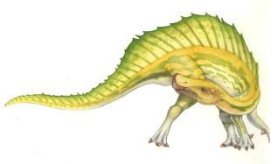


Symmetric Encryption

- Same key used to encrypt and decrypt
  - *E*(*k*) can be derived from *D*(*k*), and vice versa
- DES is most commonly used symmetric block-encryption algorithm (created by US Govt)
  - Encrypts a block of data at a time
- Triple-DES considered more secure
- RC4 is most common symmetric stream cipher, but known to have vulnerabilities
  - Encrypts/decrypts a stream of bytes (i.e wireless transmission)
  - Key is a input to psuedo-random-bit generator
    - Generates an infinite **keystream**

Asymmetric Encryption

- Public-key encryption based on each user having two keys:
  - public key – published key used to encrypt data
  - private key – key known only to individual user used to decrypt data
- Must be an encryption scheme that can be made public without making it easy to figure out the decryption scheme
  - Most common is RSA block cipher
  - Efficient algorithm for testing whether or not a number is prime
  - No efficient algorithm is know for finding the prime factors of a number



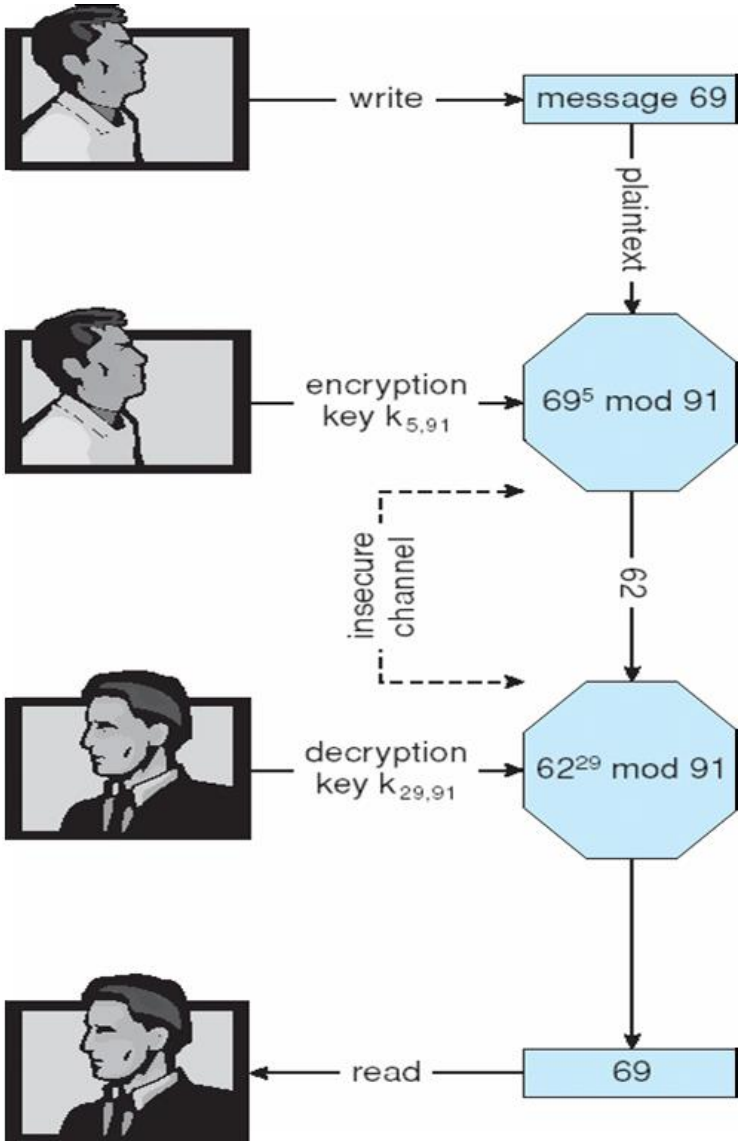
Asymmetric Encryption (Cont.)

- Formally, it is computationally infeasible to derive $D(k_d, N)$ from $E(k_e, N)$, and so $E(k_e, N)$ need not be kept secret and can be widely disseminated
  - $E(k_e, N)$ (or just k_e) is the **public key**
  - $D(k_d, N)$ (or just k_d) is the **private key**
  - N is the product of two large, randomly chosen prime numbers p and q (for example, p and q are 512 bits each)
  - Encryption algorithm is $E(k_e, N)(m) = m^{k_e} \bmod N$, where k_e satisfies $k_e k_d \bmod (p-1)(q-1) = 1$
  - The decryption algorithm is then $D(k_d, N)(c) = c^{k_d} \bmod N$

Asymmetric Encryption Example

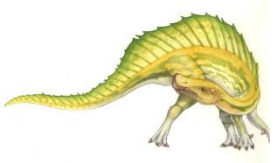
- For example. make p = 7and q = 13
- We then calculate $N = 7 * 13 = 91$ and $(p-1)(q-1) = 72$
- We next select k_e relatively prime to 72 and< 72, yielding 5
- Finally,we calculate k_d such that $k_e k_d \bmod 72 = 1$, yielding 29
- We how have our keys
  - Public key, k_e, N = 5, 91
  - Private key, k_d , N = 29, 91
- Encrypting the message 69 with the public key results in the cyphertext 62
- Cyphertext can be decoded with the private key
  - Public key can be distributed in cleartext to anyone who wants to communicate with holder of public key

Encryption and Decryption using RSA Asymmetric Cryptography



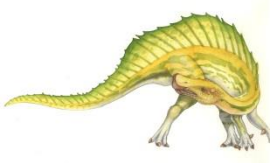
Cryptography (Cont.)

- Note symmetric cryptography based on transformations, asymmetric based on mathematical functions
  - Asymmetric much more compute intensive
  - Typically not used for bulk data encryption

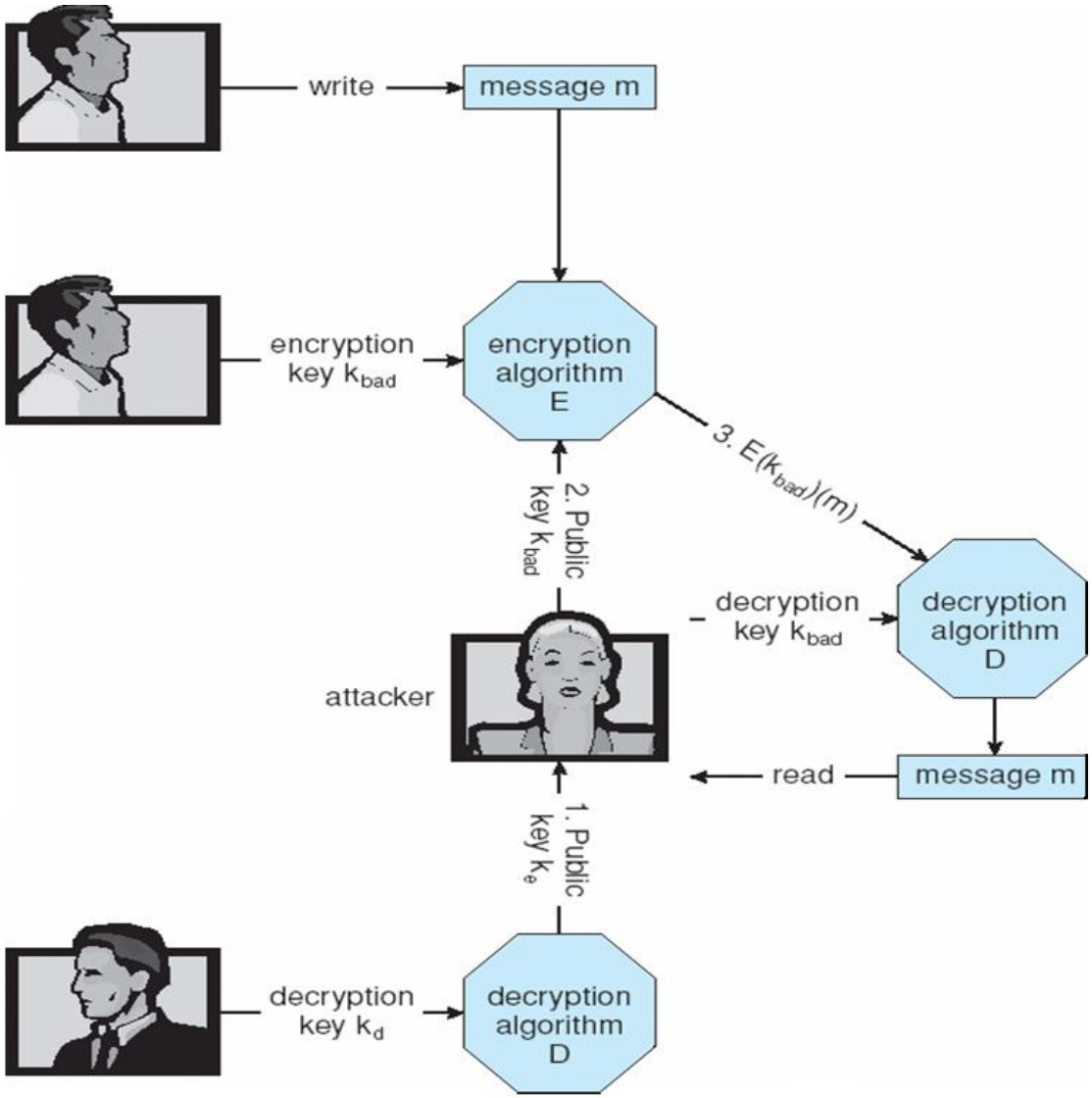


Key Distribution

- Delivery of symmetric key is huge challenge
  - Sometimes done **out-of-band**
- Asymmetric keys can proliferate – stored on **key ring**
  - Even asymmetric key distribution needs care – man-in-the-middle attack



Man-in-the-middle Attack on Asymmetric Cryptography

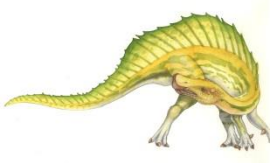


Man-in-the-middle attack

- 1. Alice sends a message to Bob, which is intercepted by Mallory:
  - Alice "Hi Bob, it's Alice. Give me your key"--> Mallory Bob
- 2. Mallory relays this message to Bob; Bob cannot tell it is not really from Alice:
  - Alice Mallory "Hi Bob, it's Alice. Give me your key"--> Bob
- 3. Bob responds with his encryption key:
  - Alice Mallory <--[Bob's_key] Bob
- 4. Mallory replaces Bob's key with her own, and relays this to Alice, claiming that it is Bob's key:
  - Alice <--[Mallory's_key] Mallory Bob
- 5. Alice encrypts a message with what she believes to be Bob's key, thinking that only Bob can read it:
  - Alice "Meet me at the bus stop!"[encrypted with Mallory's key]--> Mallory Bob

Man-in-the-middle attack

- 5. Alice encrypts a message with what she believes to be Bob's key, thinking that only Bob can read it:
  - Alice "Meet me at the bus stop!"[encrypted with Mallory's key]--> Mallory Bob
- 6. However, because it was actually encrypted with Mallory's key, Mallory can decrypt it, read it, modify it (if desired), re-encrypt with Bob's key, and forward it to Bob:
  - Alice Mallory "Meet me at 22nd Ave!"[encrypted with Bob's key]--> Bob
- 7. Bob thinks that this message is a secure communication from Alice.



End of Chapter 15